Application of Reference Curves for Dissolved Oxygen Criteria Assessment

Scientific and Technical Advisory Committee Review and Recommendations for the Chesapeake Bay Program

September 2009

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About the Scientific and Technical Advisory Committee

The Scientific and Technical Advisory Committee (STAC) provides scientific and technical guidance to the Chesapeake Bay Program on measures to restore and protect the Chesapeake Bay. As an advisory committee, STAC reports periodically to the Implementation Committee and annually to the Executive Council. Since it's creation in December 1984, STAC has worked to enhance scientific communication and outreach throughout the Chesapeake Bay watershed and beyond. STAC provides scientific and technical advice in various ways, including (1) technical reports and papers, (2) discussion groups, (3) assistance in organizing merit reviews of CBP programs and projects, (4) technical conferences and workshops, and (5) service by STAC members on CBP subcommittees and workgroups. In addition, STAC has the mechanisms in place that will allow STAC to hold meetings, workshops, and reviews in rapid response to CBP subcommittee and workgroup requests for scientific and technical input. This will allow STAC to provide the CBP subcommittees and workgroups with information and support needed as specific issues arise while working towards meeting the goals outlined in the *Chesapeake 2000* agreement. STAC also acts proactively to bring the most recent scientific information to the Bay Program and its partners. For additional information about STAC, please visit the STAC website at www.chesapeake.org/stac.

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Cover photo of the Monie Creek provided by Hilary Stevens, Integration and Application Network (http://ian.umces.edu/).

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Background

In October, 2006, the Scientific and Technical Advisory Committee (STAC) to the Chesapeake Bay Program published its recommendations for the use of the cumulative frequency diagram approach (CFD) for defining water quality criteria and to determine water quality criteria attainment (STAC 2006). In May, 2009, the Chesapeake Bay Program and its Water Quality Steering Committee requested that STAC convene a panel to review several proposed modifications in the application of the CFD approach to the benthic index of biotic integrity (Weisberg et al. 1997). The STAC review panel consisted of a subset of the original CFD panel (Mary Christman, Frank Curriero, and Elgin Perry), added Paul Jacobson and was coordinated by Doug Lipton from STAC.

The STAC panel met in Annapolis, MD, on August 17, 2009. Rich Batiuk and Jeni Keisman from the Chesapeake Bay Program presented technical materials and responded to queries from the review panel. The panel was provided in advance a briefing document (Application of Reference Curves for Dissolved Oxygen Criteria Assessment: Chesapeake Bay Program Office Review and Recommendations Briefing Document June 4, 2009). Additional documents provided included a technical memorandum from the Virginia and Maryland Associations of Municipal Wastewater Agencies (V/MAMWA) prepared by Clifton Bell of Malcolm Pirnie Inc dated June 18, 2009, and the Chesapeake Bay Program response to that memo dated July 13, 2009.

Committee Report and Recommendations

In general, the Committee found that the Bay Program's proposed adjustments in implementing the benthic index of biotic integrity (B-IBI) and the cumulative frequency distribution curve were sound and well-justified. We encourage the Bay Program to continue to work towards implementing improvements recommended in the earlier STAC review, as well as some additional items identified below.

The Water Quality Steering Committee and the Chesapeake Bay Program requested STAC input on the following specific questions:

Question 1: Is the Chesapeake Bay benthic index of biotic integrity (B-IBI) being applied in a manner that accurately identifies those "healthy" segments with "acceptable" DO violation rates?

No. As originally implemented the B-IBI was not efficiently distinguishing healthy segments with acceptable DO violation rates. See the Committee response to question 2 below for more detail regarding the proposed modifications that address this concern.

Question 2: Assuming reasonably accurate identification of groups of "healthy" and "degraded" benthic communities and their associated violation rates, should the methodology used to construct the biological reference curve be modified? Specifically, should the biological reference curve be constructed in a manner that distinguishes between the two datasets of "acceptable" and "unacceptable" DO violation rates with

minimal error? This would be in contrast to the current published method, which simply pools all acceptable violation rates into one biological reference curve.

Yes. As described in the background documents, the previous method of calculating a reference CFD curve performed poorly in terms of discriminating between healthy and unhealthy segments. The review committee determined that the changes proposed by the Chesapeake Bay Program to calculate reference curves are appropriate, based on sound scientific reasoning and will likely lead to an improvement in the application of the methodology in determining impairment.

Specifically, we agree with the decision and provide the following set of recommendations:

1) To truncate the time series of benthic data used from 1985-2006 to 1996-2006. This decision is based on a change in the sampling design and provides a more consistent dataset for analysis.

2) Use a 3-year rolling average of B-IBI scores and 3-year windows of DO to calculate the reference curve to make it consistent with the 3-year window used to assess DO levels in segments. The Review Committee agreed with this approach as a logical and appropriate use of moving averages. However, the Committee pointed out that from a statistical viewpoint, the approach reduces the effective sample size, since the data used to construct points in the CFD are no longer independent observations due to the overlap in the rolling average. The Committee did not feel that this would create any immediate problems in the proposed applications, but felt it was important to point out to the Bay Program. This modification addresses a concern raised by the earlier STAC review of the CFD which noted that sample sizes for reference and assessed conditions should be made similar to reduce the effect of sample size bias on the shape of the CFD.

3) Require that the B-IBI score only be calculated from segments with a sample size greater than or equal to 10. The decision to eliminate segments with fewer than 10 observations was based on an analysis of the data and ability of the reference CFD to appropriately classify segments. The determination of a minimum sample size of 10 was deemed reasonable and his been applied elsewhere (e.g., Alden et al. 2002).

4) Use an average B-IBI score of greater than or equal to 3 and a standard deviation of less than one to classify segments as healthy. In general the Committee agrees with the approach, but has several recommendations that we believe will strengthen the justification.
    a. A sensitivity analysis on the assumption of an average B-IBI score of 3.0 should be conducted similar to that for sample size and standard deviation.

    b. Based on assumptions of normality (see below), the criteria for the standard deviation should be expressed as: "no more than 16% of the sample observations should have a score of less than 2.0". Note that this is a one-sided version of the criterion which addresses the committee concerns that clearly healthy segments with a high variance would be excluded using the proposed criteria. The results from moving to this criterion should be evaluated against the current approach to determine if the ability to discriminate healthy segments remains as good or improves using the one-tailed approach.

c. Test for normality of the B-IBI scores by running analysis of variance (ANOVA) using sample year and segment as treatments and examining residuals compared with expectations for normal or truncated normal distribution.

5) Use the 100th percentile of healthy violation rates to construct reference CFD. Observations showed that the 100th percentile best discriminated between healthy and unhealthy segments and the Committee agreed with the approach. The Committee pointed out that due to the relative small sample size, the curve would likely shift to the right, *ceteris paribus*, as more data is obtained to construct it. However, we would expect other factors to change the curves as well and concluded that the current approach produced the best results with currently available data. Thus, there should be plans to periodically reevaluate the criteria as more data becomes available.

Question 3: Is a B-IBI based biological reference curve the most appropriate reference curve to apply in assessing attainment of the Chesapeake Bay June-September 30- day mean open-water dissolved oxygen criterion?

No. Figure 4 in the provided background material clearly shows that the B-IBI offers no discrimination between good DO and bad DO conditions and this is supported by our understanding of the ecology. The proposed alternative 10% curve has precedent in being applied in similar situations where a defensible biologically-based reference curve has not been developed. Clearly, an appropriate metric needs to be developed for open water, but until a defensible one is developed, the 10% curve is appropriate, based on EPA precedent.

Question 4: Is it appropriate to apply a biological reference curve for assessing attainment of the Chesapeake Bay deep-channel instantaneous minimum dissolved oxygen criterion?

Yes. The concept of acceptable exceedance applies to an instantaneous criterion the same as to other duration windows (e.g., acute, chronic criteria). Exceedances of sufficiently low temporal frequency do not necessarily result in impairment. They may cause harm, but not preclude attainment of the designated use. If data existed to develop a biologically-based curve it would be an improvement over 10% curve, but currently there are no data from which to construct such an alternative.

Literature Cited

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